Determining the scope of an assessment framework for 3Ps cod

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Canadian Technical Report of Fisheries and Aquatic Sciences

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A ‘Scoping meeting’ was held on 20th October 2017 to map out the main steps in preparation for the 3Ps cod assessment framework. The scope for developing the assessment framework for 3Ps cod is very broad and involves at least three different steps: (i) data review, (ii) stock assessment model development, and (iii) final review of model performance. Data review can take one year. Data type specific objectives were noted for most data types discussed at the scoping meeting. There was agreement to organize a meeting to present and discuss the review of input data and decide which data are appropriate for use in the assessment framework. The data review meeting is to be held as a two-day addition to the autumn 2018 3Ps cod assessment. The goal for the proposed meeting is to finalize, to the extent possible, the input data that will go ahead into the modelling process. Based on the outcomes of the data review process, the second step will be to discuss modelling approaches in greater detail than outlined in this report. It was agreed that a steering committee would be struck to manage the process and progress of the assessment framework for 3Ps cod.

RÉSUMÉ

Varkey, D.A., Wheeland, L.J., Ings, D.W., Healey, B.P. 2023. Determining the scope for an assessment framework for 3Ps cod. Can. Tech. Rep. Fish. Aquat. Sci. 3504: vi + 19 p.

Une réunion d’établissement de la portée a eu lieu le 20 octobre 2017 afin d’évaluer les étapes principales de la préparation du cadre d’évaluation du stock de morue 3Ps. La portée du cadre d’évaluation de la morue 3Ps est très vaste et comprenant au moins trois étapes: (i) l’examen des données, (ii) l’élaboration du modèle d’évaluation du stock, et (iii) l’ évaluation des performances du modèle. L'examen des données peut prendre un an. Des objectifs spécifiques au type de données ont été notés pour la plupart des types de données discutés lors de la réunion. Il a été convenu d’organiser une autre réunion afin de présenter et de discuter des données disponibles et de décider lesquelles sont appropriées pour être utilisées dans le cadre d’évaluation. La réunion d’examen des données se tiendra au cours de deux jours en plus de la réunion l’évaluation de la morue des 3P de l’automne 2018. L’objectif de la réunion proposée est de finaliser, dans la mesure du possible, les données d’entrée qui vont être utiliser par la modèle d’évaluation du stock. Selon les résultats d’examen des données, la deuxième étape consistera à discuter plus en détail des approches de modélisation. Il a été convenu qu’un comité directeur serait mis sur pied pour gérer les progrès du cadre d’évaluation de la morue des 3Ps.

INTRODUCTION

What is an Assessment Framework?

An assessment framework is an iterative and collaborative process that leads to the development of a new/improved methodology for assessment of a stock. The goal of the new methodology is to improve the approaches to quantify stock status and in the case of 3Ps cod, characterize the influence of fisheries on the stock status. Additionally, the assessment framework process provides opportunity to thoroughly review data available for the stock, explore ecosystem influences on stock dynamics, consider precautionary approach reference points and evaluate whether additional data collection would be needed. Further this process encourages dialogue and exchange of ideas between the different entities involved in the management of the stock in question.

Why the need for an assessment framework for 3Ps cod?

A zonal meeting in 2010 noted the need the investigate new analytical methods for the stock (DFO 2010). Previous scientific assessments of the stock have also documented (DFO 2012; DFO 2017a) the need to improve current assessment methods to provide advice on stock and fisheries status. A “strong directional retrospective pattern” in the estimates of spawning stock biomass and stock status has been noted in recent assessments (Rideout *et al*. 2017). The current survey-based modelling approach (SURBA) does not include catch records in the estimation process. Reliability of the landing data has varied over time (Halliday and Pinhorn 1996), preventing the use of the landings time-series directly in a population model for the stock, hence the model currently used to assess 3Ps cod estimates total mortality; it is unable to separate the effects of fisheries and natural mortality on the stock. There is need to develop methodology that will incorporate catch data into the assessment method, and thus be able to characterize the effect of fishing pressure on the stock and provide better advise to management in terms of catch projections and resultant effects on stock status.

Collaborators

The scoping meeting was attended by participants from DFO (Fisheries and Oceans Canada), IFREMER (Institut français de recherche pour l'exploitation de la mer), MI (Marine Institute, Memorial University, Newfoundland), NL-DFFA (Newfoundland Department of Fisheries, Forestry and Agrifoods), the GEAC (Groundfish Enterprise Allocation Council), and FFAW (Fish, Food and Allied Workers Union).

Fish stocks within the NAFO sub-division 3Ps are jointly managed by Canada and France. The 3Ps boundaries include Canadian waters south of Newfoundland and waters around French overseas territory of St. Pierre et Miquelon. The development of the assessment framework will involve collaboration between scientists at DFO and IFREMER. It is anticipated the project will come under the auspices of both the Canada-France Process-Verbal agreement as well as a scientific project MOU signed by DFO and IFREMER in 2015. The concept of a targeted project to prepare for and complete a framework assessment has been discussed by both scientists and senior managers from Canada and France. However, details regarding funding and personnel still remain to be finalized. Canadian and French researchers will contribute to the development of the assessment framework.

DFO has previously collaborated with academics at the Marine Institute on the development of an assessment framework for Northern cod and there is an opportunity for their involvement with the 3Ps assessment framework development. Further, this process is incomplete without industry involvement, whose inputs are very valuable, for example, related to an improved understanding of catch history for the stock.

Purpose of the Scoping meeting

The purpose of the 'Scoping meeting' held on 20th October, 2017 was to determine the major steps for the development of an assessment framework for 3Ps cod, discuss available data for potential inclusion in the assessment framework, discuss key aspects of the stock population dynamics, brainstorm initial ideas on assessment model development, and discuss the process of review and decision making for the assessment framework.

This document serves as a record of discussion from the scoping meeting, and was circulated to all participants for review and comment on 11 December 2017 (with a follow-up reminder on 10th January, 2018).

Outline of major steps for the Assessment framework

STEP 1: Thorough review of data

a. List all data sources
b. Review of data: The reliability of each source will be reviewed and documented for the purpose of inclusion in the assessment model. To perform this exercise in a systematic manner, a questionnaire will be designed for data evaluation and review.

STEP 2: Development of alternate models

a. Discuss population dynamics: key model parameters – how these are structured in the model.
b. Discuss ecosystem influences on the stock and whether any such aspects could be explicitly included in population models.
c. Discuss alternate model structures
d. Review objectives for the fisheries
e. Build the alternate models

STEP 3: Review of Assessment framework

a. Review model outputs and model performance

b. Final decision/conclusion
    i. Approve a model as the assessment methodology going forward
    ii. Decide on important data for collection as input going forward

Details of major steps for the Assessment framework

STEP 1 – THOROUGH REVIEW OF DATA

I. RESEARCH VESSEL SURVEY INDEX DATA

1. Survey index data standardization

OBJECTIVE: Improve abundance index information by considering spatial variation in sampling, population distribution, survey timing, methodology, and habitat covariates.

OBJECTIVE: Re-analysis of index standardization, with a focus on including index uncertainty and sensitivity to large-catch events in the stock assessment model. The goal is to (1) obtain realistic estimates of uncertainty in the survey data, and then (2) determine how to incorporate these into the assessment models.

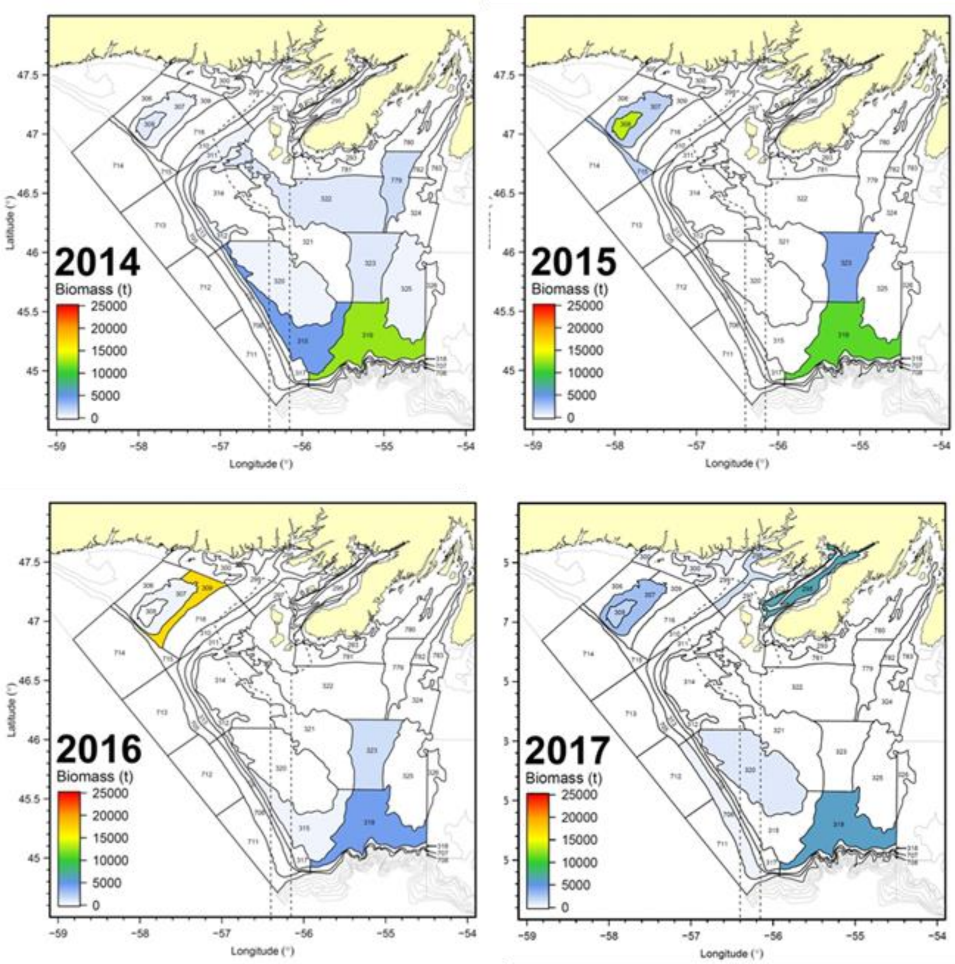

Figure 1. Stratum-specific biomass estimates of cod in Subdiv. 3Ps based on the DFO RV survey.

Research vessel surveys are the primary source of information regarding changes in stock status. The 3Ps research vessel survey indices show considerable inter-annual variability. From a spatial perspective, a small number of strata (less than 5 out of a total of 45) contribute disproportionately to the biomass index calculation and there is potential to bias the overall survey index for the region. The year/spatial effects may be a combination of environmental factors, movement, aggregation, or others, so there is a need to disentangle the year-effects and spatial aspects and improve our approach to survey standardization. The analysis will evaluate survey data at the set level rather than at the strata level and explore alternate methods of index standardization. Index standardization approaches to be explored include:

> **STRAP** (Smith and Somerton, 1981): This is the current approach to calculate the overall index data where the set by set index data from each strata are raised to the overall estimate based on strata delineations in the sampling design. This is a statistically unbiased indicator with the

assumption that each stratum in the survey is independent and adequately represented by a mean and standard deviation for within-strata abundance.

Post-stratification (Smith 1991, Dressel and Norcross 2005, Cochran 2007): This is a methodology to improve the survey estimates by aggregating information from similar strata. After the survey, the samples are reallocated to different strata combinations. The main goal of the approach is to reduce between year variance in the survey estimates.

OGMAP (Evans 2000, Evans et al. 2000): OGMAP is a package developed in Python for non-parametric kriging approach to spatial data analysis. This approach has been applied to the estimation of survey biomass and abundance of a couple of shrimp stocks in the North-Atlantic. It includes the potential to add covariates into the calculation of spatial population distribution. It is not currently formulated to analyze age disaggregated data.

VAST (developed by James Thorson https://github.com/James-Thorson?tab=repositories**):** VAST applies a geostatical model to spatial survey data. This approach has been simulation tested and applied to groundfish populations in the Pacific (Thorson et al. 2015) and northern shrimp in the Gulf of Maine (Cao et al. 2017).

The options discussed were to apply these methods and compare their performance, or ideally test the performance within a spatial simulation exercise. Dealing with year effects would be a significant focus of these analyses, especially how the year effects may be disentangled from spatial effects. Further, survey timing is important from a fish movement perspective; the spring survey occurs around the time when the fish are believed to be moving inshore after period of high aggregation in the offshore. However, we do not expect to include timing and movement aspects in the above discussed approach for survey standardization especially because: (i) there is no complementary information available on when fish movement occurs and (ii) movement timing probably differs between years and fish age-classes.

It was noted that consideration of inclusion of covariates such as temperature and habitat may be worthwhile, but challenging to do and it might not be appropriate for all models. Some preliminary concerns were raised over using temperature as a covariate considering that temperature data was available only at the sampling sites. A spatial interpolation of temperature may be an avenue to explore, though there are questions regarding additional uncertainty added through the interpolation vs. potential for providing useful information on cod distribution. Covariates might inform year effects, provide insight into compression/expansion of available cod habitat, and inform distributional patterns.

Two options for treatment of spatial survey data were discussed:

a. **Analyse survey data using geo-statistical or other spatially explicit methods.** Some considerations relate to how distance is considered (straight line distance vs. distance along the bottom; influence of bathymetric barriers to movement). Edge effects are likely to have impacts within geo-statistical models as these methods tend to be biased towards the boundaries of the area being considered. However, geo-statistical methods do not assume that strata are independent and may be better able to account for similarities between sites located near strata boundaries.

b. **Use the strata as discrete sampling units** with the possibility of using a post-stratification scheme in order to make strata larger and more representative of variation in habitat. Large strata may currently incorporate multiple habitat types and post-stratification might allow a more informed index calculation. The caveats include the need to account for non-uniform sampling intensity if strata were to be combined.

Survey index uncertainty

The geo-statistical models will be able to quantify the uncertainty in the index data, but it is unclear how this uncertainty could be incorporated into a stock assessment model. There is potential to collaborate with REDUS (Reduced Uncertainty in Stock Assessment) project with Institute in Marine Research, Norway. An upcoming collaborative national research program (3yr) on assessment processes was also discussed. Several classes of models that incorporate survey errors in the estimation process were discussed.

2. Ageing of the survey index data

OBJECTIVE: Explore need to incorporate information from spatially dis-aggregated age-length keys for aging the survey data in the 3Ps region.

In current practise, a single age-length key (ALK) is applied to the lengths of all fish recorded in each year of the spring survey. However, age-length keys are regularly developed for six subunits within the 3Ps boundaries. Therefore, there is potential to develop more ALKs for smaller areas to capture some spatial variation in length-age structure. Current sampling protocol needs to be documented along with clear distinction of time periods when ALKs are available for the six subunits in the survey area. Further, analyses will be conducted to determine if there is evidence of spatial variation in the age-length keys. Any variation will warrant a change from the current approach of producing survey abundances at age. Further, within an integrated model, length data and the spatial age-length keys can be added as input data; the model would carry forward the uncertainty in estimating survey abundances at age. This suggestion depends on feasibility of the task within the modelling approaches to be developed for the assessment framework.

3. Time series of survey index data

OBJECTIVE: Consider survey methodology changes over time as an important issue to address in the framework development. Review what has been done with the conversions of data from the bottom trawls used previously on the DFO survey and determine which survey data are appropriate for use in the assessment model.

The survey gear was switched from Yankee trawls to Engel trawls in 1983 and from Engel trawls to Campelen trawls in 1996 in 3Ps. After the introduction of Campelen gear, comparative fishing experiments were conducted to adjust the catchability at age/length of fish in the surveys using Engel trawls (McCallum & Walsh 1996). The current SURBA model uses survey data from 1983 onwards; the main question is if the older indices (1972 to 1982) are suitable for use in the assessment model development. For this, an improved understanding of the findings from the conversion experiments for switches between Yankee, Engel, and Campelen survey series is required. In addition to using information from the comparative fishing on differences in selectivity, additional considerations include changes in survey timing and survey coverage (for example, addition of inshore strata in mid-1990s). There might be some additional information gleaned from details such as trawl measurements (wing spread, swept area, habitat etc. although previous consideration of these factors did not indicate any relationships) for the calculation of indices

A related question is if there is opportunity to include older ages in the model development. The currently used SURBA model uses data for fish up to age 12. A maximum age of 12 years was chosen as there were many instances of no survey catches beyond age 12, and the SURBA model estimation approach treats that as no information (i.e. a missing data point). The use of ages older than 12 is also related to the difference in catchability/selectivity between the different survey methodologies. There is the option to input unconverted indices into the assessment model, followed by data from the conversion experiments, and allow variation in assessment model structure to estimate catchability changes between the different index series.

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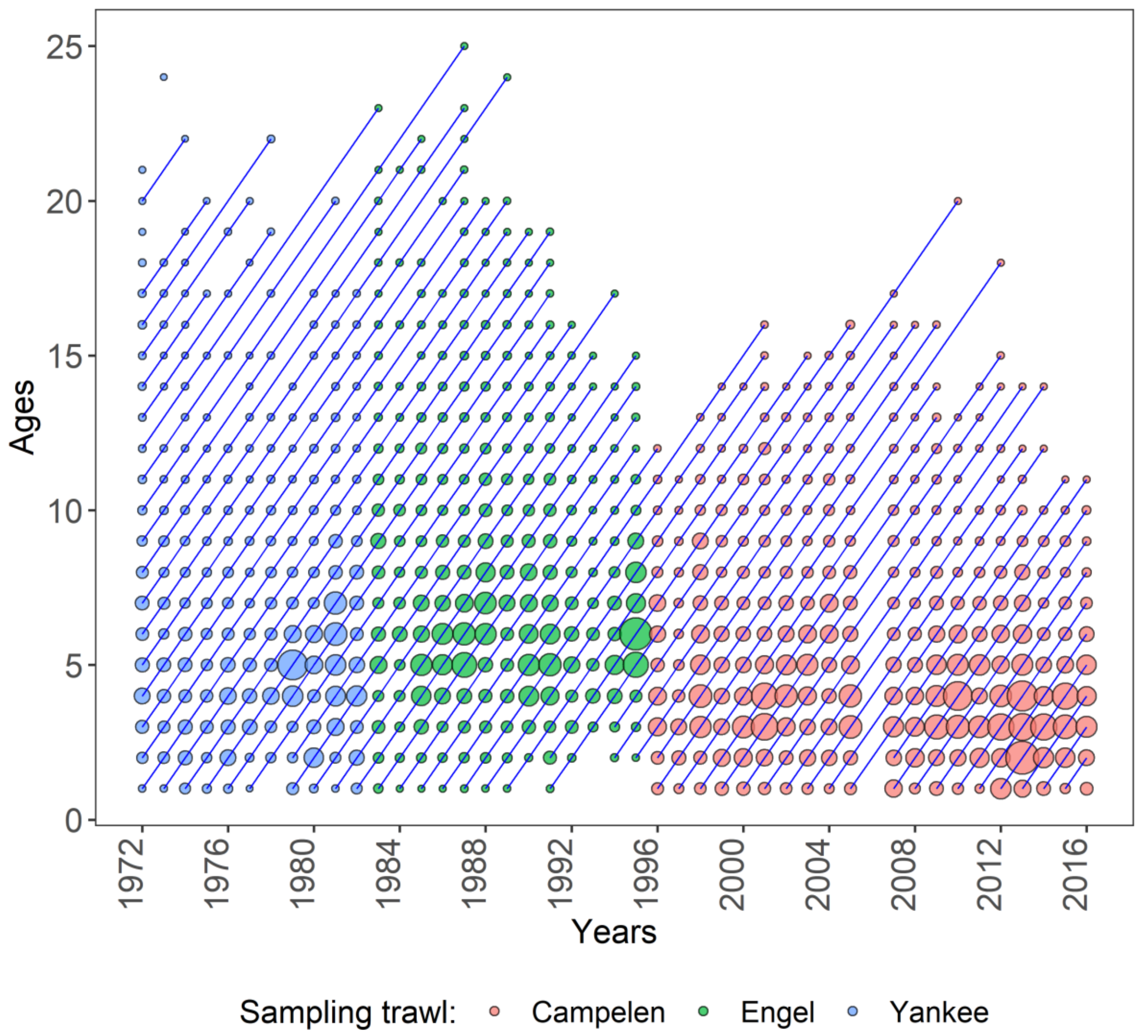

Figure 2. Survey time series by age. The colours represent survey gears. The size of the bubbles show log abundance at age (no conversion factors applied, thus only comparable within each colour). The blue lines follow a cohort by year and age in the survey.

II. OTHER SURVEY DATA

OBJECTIVE: Determine what other survey data may be available and suitable for use in the Assessment framework.

Some of the additional survey data available include the following:

French winter/spring surveys: Bottom trawl surveys were conducted from 1978 to 1992 by French research vessels and have been previously used in the contemporary assessments of this stock (Brattey et al. 1999). The French surveys followed similar design of DFO survey but the vessels were different; (Bishop *et al.* 1994). The data from these surveys need to be reviewed and conclusions made regarding their value for the assessment framework.

Industry survey: The Groundfish Enterprise Allocation Council (GEAC) conducted surveys in fall in 3Ps in years 1997 to 2005 and 2007 (McClintock 2011) with major focus on cod, American plaice, and witch flounder (McClintock 1999). The data from these surveys need to be reviewed and conclusions made regarding their use in assessment models being developed for the assessment framework.

Sentinel survey : The sentinel survey began in 1995. Sentinel sampling is limited to coverage in the inshore areas and over time there have been some change in sites and overall coverage. Lengths, weights, and ages are recorded from the sentinel samples. Among the different types of data collected, the most important data are probably the fish age compositions. Sentinel indices may be most useful in a spatially explicit model which can characterise differences between inshore and offshore areas. For the assessment framework, there is a possibility to rethink standardization of sentinel fishery based on the selectivity of the different mesh sizes.

Acoustic surveys: There are two sources of acoustic data: (i) Acoustic surveys in the 1990s (Brattey et al. 1999; O'Driscoll and Rose 2001; Rose et al. 1995) mapped the cod populations in Newfoundland waters; however more information is needed on spatial and temporal extent of the coverage in 3Ps. (ii) Acoustic data from multispecies surveys, which is a recent addition to the survey program. It is currently unclear if any standardized acoustic data is available for 3Ps cod. It is recognised that processing acoustic data is not a trivial undertaking and it is not clear at this stage whether the limited acoustic data available could be used to provide information for the assessment model. There is a possibility that survey acoustics could contribute covariate information for survey index standardization. However, a joint acoustic-trawl index standardization is not possible within the scope of the assessment framework for 3Ps cod. Efforts will be made to document the nature of acoustic data available and assess the value of such data for the assessment framework.

III. FISHERIES DATA

1. Landings/ Total catch

OBJECTIVE: Assess the quality and reliability of historic and current catch data to determine uncertainty, bias, and applicability of catch data for the modelling approaches to be developed. Review if it is possible to separate the catch data by fleets, or by sectors (inshore vs offshore).

The reliability of the catch data for 3Ps cod has varied over the years (Halliday and Pinhorn 1996). It is understood that there is more confidence in catch data from recent years. Landings data exist from 1959 to present; the period covered by the current SURBA model is 1983 to 2017, although landings data are not part of this analysis. Reliability issues relate to catch by foreign fleets prior to EEZ delineation, quota share determination post EEZ delineation; seasonal closure to avoid capture of 3Pn4RS fish, discards, trip limits etc. but information is not available to quantify the level of uncertainty across the time series. It is important to acknowledge this uncertainty and estimate uncertainty bounds on this data prior to our being able to reliably use this data in a new assessment model.

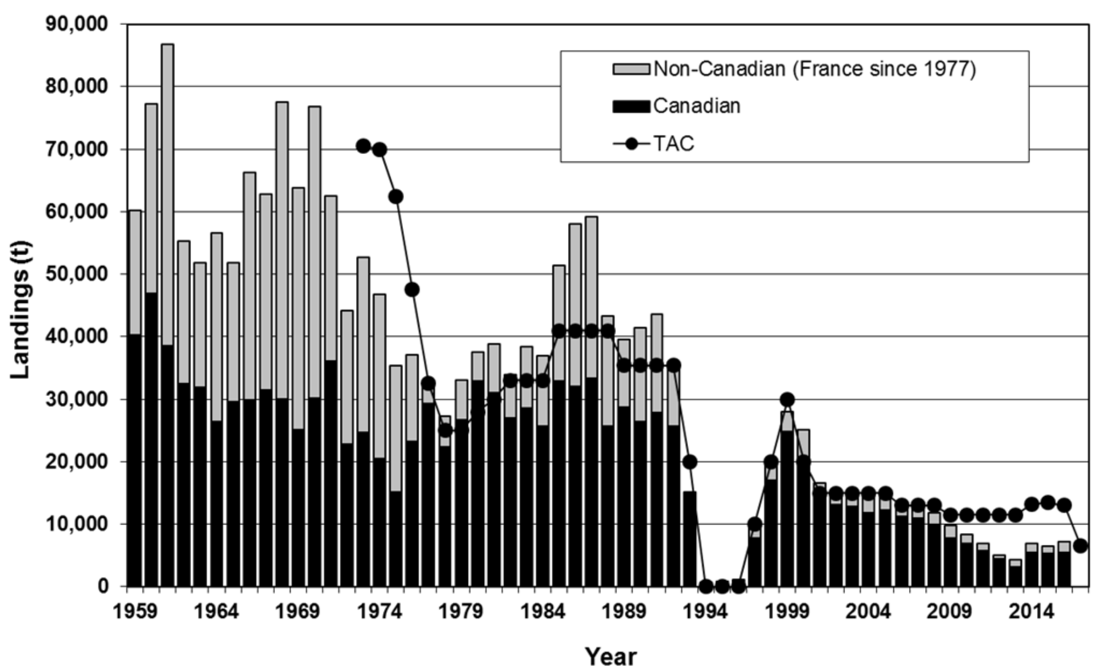

Figure 3. Reported landings of cod by Canadian and non-Canadian vessels in NAFO Subdiv. 3Ps.

Auditing the catch data is important to understand reliability; some verification is possible through comparison with logbook information but logbook coverage is partial compared to the extent of the fishery. A suggestion was made to document annually during the assessment process any reported problems in the fishery; acknowledge the problems and add information on how the problem was identified and/or what checks were in place to avoid the problem in future (for example, high-grading recorded in Healey et al. 2011). Where suitable, efforts could also aim to estimate the uncertainty to be added to the data on account of the recorded problem. A successful audit of the catch data needs perspective of the industry regarding the history of the fishery and therefore needs strong participation from industry.

2. Catch-at-age data

OBJECTIVE: Reconsider stock weights and catch weights and how these are used within the model. Determine variation in weight at length annually and if needed seasonally and spatially. Incorporate any required changes in the length-weight conversions.

In the calculation of catch weight at age, the current approach uses catch length frequency and age-length key from the current year, quarter, and spatial sub-units within 3Ps. However, the catch length at age data is converted to weight at age by applying an invariant length-weight relationship throughout the time series. It is unclear how much bias is introduced by using an invariant length-weight relationship. It was proposed to investigate if there has been a change in length-weight relationship over time that has introduced a bias in the calculation. The next step is to investigate the possibility of estimating weight at length relationships using spring research survey samples and using these relationships to calculate catch weights adjusted for the time of the catch records. The sentinel time-series does have some weight at length information for approximately a ten week duration which is longer than the survey period. There is also additional seasonal information on lengths and weights from tagging studies. The goal is to determine whether fisheries data or research survey data should be used to produce stock weights for the assessment model.

3. Fisheries CPUE

It is unclear whether the fisheries catch per unit effort (CPUE) data can provide any reliable information about stock health because information on effort is not complete. The commercial fisheries license agreements require reporting of catch but not of effort. There are other factors too such as changes in fishing practices, participation in fisheries (for cod and for other species which may impact cod directed effort), and product pricing which affect the CPUE trend series. Considering these issues, this data has low priority for inclusion the assessment framework.

4. Various logbooks

There are concerns over the reliability of CPUE trends from commercial logbooks and there is need to assess reliability of the catch and effort information available from these. Further, recent return rates of inshore fleet logbooks have been lower than in the past and it is unclear whether the data gathered are representative of the fishery.

5. Additional fisheries data sources

Additional fisheries data are available on fisheries on 3Ps cod from French waters. All the factors that apply to the data aspects of the Canadian catches most probably apply to this data as well and a similar review is required for the total landings, catch-at-age, and fisheries CPUE data.

IV. TAGGING DATA

OBJECTIVE: Examine the movement of 3Ps cod relative to adjacent areas

Tagging data sources are the following: 1. Current inshore tagging effort, 2. Early 2000s: tagging in the offshore, and 3. Releases from 2J3KL recaptured in 3Ps. Updated information on 3Ps releases captured within 3Pn4RS is required. The main potential uses of tagging data are to estimate:

(A) **Natural Mortality:** Investigate if the tagging effort to date has been sufficient to provide enough data for estimation of natural mortality. A suggestion at the meeting was to look into changes in the rate of tag returns over the years (rather than the magnitude) to infer changes in natural mortality. In this context, it was noted that recovery of fish tagged offshore in 3Ps was poor (Pope and Brattey 2001). Tagging data has been previously used to estimate harvest rates but these were based on assumed natural mortality levels (Pope and Brattey 2001; Brattey ahd Healey 2003, DFO 2008).

(B) **Movement:** Tagging data may provide a record of movement. Some concerns include contraction of tagging effort (releases) in recent years, and poor recovery in offshore areas combined with small exploitation rate in many areas limiting potential for recaptures across space.

Several research documents (Pope and Brattey 2001; Brattey 1996; Brattey et al. 2001, and others) provide information on findings from tagging studies. The plan is to review existing information and explore if any conclusions can be made with to regard to (i) how much fishing outside of 3Ps boundaries impacts populations within 3Ps, (ii) how much movement occurs between stock areas, (iii) and how movement varies seasonally. The final caveat is that most of the information on stock movement is historical and it is unclear how relevant this is to the current stock structure. Other options to track movement include (i) following year classes in catch & surveys in neighbouring stock areas, (ii) looking at existing catch data and investigating if there is potential for otolith microchemistry research to detect differences in spatial signature over time. However, some of these options might be impractical within two years and the data review should make the necessary conclusions.

V. OTHER DATA CONSIDERATIONS

DFO is currently rebuilding port sampling applications, so there is opportunity for new data to be collected and it is best to make related decisions sooner rather than later. It was proposed to include additional “blank” fields that could be populated after, in anticipation of future sampling needs.

VI. FINAL DATA REVIEW

> OBJECTIVE: Host meeting to present and discuss the review of input data and decide which data are appropriate as model inputs. It was decided that the best way forward would be for this meeting to be held as 2 day addition to 2018 3Ps cod assessment
>
> At this meeting, finalize, to the extent possible, the input data that will go ahead to the modelling process as well as document agreed quality of all available input data.
>
> Efforts will be made to engage external experts in the data review meeting.

The final data review involves applying a data questionnaire to all data sources described above to determine the value of the data in the development of the assessment framework for modelling and post-modelling comparative purposes. Following are questions from the questionnaire adopted for the Northern Cod Assessment Framework in 2015 (DFO 2016).

1. How are the data collected?
2. Has the design changed over time?
3. How are the data analyzed?
4. Are there estimates of uncertainty?
5. Does this dataset provide an index of stock size?
6. How do these data contribute to assessment of stock status?
7. Are the analysis methods, including uncertainty estimates, appropriate?
8. Are there suggestions for improvements or recommendations for further research?

There was a suggestion to improve the questionnaire based on the SEDAR process (SEDAR 2016) adopted in the US. The plan is to investigate similar questionnaires used in other jurisdictions.

Decisions on the input data will be needed before diving into the extensive modelling. However, anticipating the model structure will also be useful in identifying data needs (e.g. fleet specific catches, etc.). We anticipate that the data review process would require one year. This process will (i) further document the existing data for 3Ps, (ii) document any concerns related to specific data, (iii) provide the decision for inclusion (or not) in the assessment framework with supportive reasoning. A meeting for a data review including the responses to the questionnaire will be held before finalizing model inputs and modelling approaches.

STEP 2 – DEVELOPMENT OF ALTERNATE MODELS

I. DISCUSS POPULATION DYNAMICS

This discussion involves the listing of key model parameters for describing the population dynamics of a stock and discussion of how these parameters would be incorporated in the model structure. One of the primary goals of the 3Ps assessment framework is to develop capacity to separate total mortality into natural and fishing mortality to potentially provide catch-based advice to fisheries managers.

1. **Fishing mortality:** Some of the issues to consider on fishing mortality estimation are the following:
    a. Will selectivity be modelled? How will the fishing mortality at age and year be estimated? If selectivity is modelled, would it be constant across years or variable based on changes to fleet structure. Will selectivity blocks be included or be modelled as a random walk process?
    b. Is it necessary to design a model that will be able to separate the different fleets? This in part depends on whether we can separate the catch-at-age data by fleets. Currently, catch-at-age data separated by fleet is not available prior to 2011, but it might be possible to extract these data from the data repository. An option might be to separate catch into inshore and offshore components in the models.

2. **Natural mortality**: What are our assumptions about natural mortality for 3Ps cod? Will this parameter be modelled as constant, or allowed to vary based on time-series blocks (e.g. pre and post moratorium), or random walk, or AR processes? Do we have any hypotheses related to trends in natural mortality owing to parasitic infections, or change in system productivity affecting growth and influencing overwintering and spawning mortality?

3. **Growth**: Recent survey indices indicate a decline in length and weight at age. Growth could be considered within the model with a growth function, or externally in the treatment of input data. A suggestion is to investigate trends in growth and condition.

4. **Recruitment**: In SURBA, recruitment is currently modelled as a random process, but there is possibility to explore other options, such as dependence on SSB (Beverton-holt model or others). This approach, however, brings in the complexity of estimating stock-recruit parameters for the stock.

II. ECOSYSTEM PERSPECTIVE

Although there was limited time at the scoping meeting to discuss potential ecosystem effects with respect to 3Ps cod population, it was recognized that dynamics of cod populations with other species in the ecosystem (similar to Holsman *et al.* 2012) should be considered in the framework process. This could include – but should not be limited to – an analysis of the ecosystem production potential (DFO 2017b) in 3Ps.

III. ALTERNATE MODEL STRUCTURES

There are several advantages to developing models with different structures during the assessment framework process. Alternate models allow alternate treatment of data and provide the opportunity to explore what model structures are most appropriate for the type of data (including uncertainty) available for the stock. Alternate model structures allow evaluation of conclusions robust against built-in structural uncertainty. Finally, exploring different model structures helps in decision making on appropriate assessment approach for the stock. We list a few model structure options but no decisions were made in this regard. Any final decisions will be pending the final data review in Step 1.

Model structure options:

1. SURBA: This is the current model structure and it is important to include our current model in the assessment framework process to evaluate the changes to conclusions resulting from including new data and changing the model structure. Some recent alternate formulations of SURBA are as follows:
    a. Inclusion of year effects in the survey
    b. Changes to specification of total mortality
    c. Splitting total mortality into time-blocks (for example, pre and post moratorium)
    d. Inclusion of process error in the model.

2. CATCH-AT-AGE MODEL: Inclusion of catch-at-age data in the analysis can be made possible through several different model structures such as VPA, SCAA, SAM style model (similar to Greenland Halibut model for

Subarea 2 and Divisions 3KLMNO and NCAM model for Northern Cod in Divs. 2J3KL), or a stock synthesis model.

3. SPATIAL MODEL: Building a spatial model for 3Ps cod is an ambitious goal; there are several caveats related to whether tagging/other data can provide information on spatial structure and movement between zones. Further, feasibility will depend on whether it is possible to split input data such as catch-at-age by spatial areas.

IV. FISHERY OBJECTIVES

It is anticipated that there will be greater clarity on the objectives for the fishery based on IFMP and the outcomes of the rebuilding plan process in Fall 2018. Objectives for the fishery can help guide model development. Guidance on approaches to present model outputs, criteria for model selection, and ability to produce catch/effort recommendations will be appreciated.

STEP 3 –ASSESSMENT FRAMEWORK REVIEW

A full review of the assessment process will be conducted after completion of Steps 1 and 2 for data review and model building. Among other aspects, the review process will include review of models, and how the outputs of models compare with respect to findings about stock status and findings about the fishery. Model performance will be reviewed and final decisions will be made regarding approval (or not) of an assessment methodology, need for additional data collection for the stock, and short term strategies for the CSAS process. External experts will be engaged to participate in this review.

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